

WHAT IS CLAIMED IS:

1. A survey tool for determining an orientation of the survey tool within a borehole, the survey tool comprising:

a plurality of rotation sensors, each rotation sensor having a sensing axis and a direction of least acceleration sensitivity, each rotation sensor adapted to generate a first signal indicative of a detected angular rotation rate about its sensing axis, the plurality of rotation sensors mounted in a housing with their sensing axes generally parallel to one another and with their directions of least acceleration sensitivity generally non-parallel to one another;

a plurality of acceleration sensors mounted in the housing, each acceleration sensor having a sensing direction, each acceleration sensor adapted to generate a second signal indicative of detected acceleration along its sensing direction; and

a controller adapted to receive a first signal from each of the plurality of rotation sensors and a second signal from each of the plurality of acceleration sensors, the controller adapted to calculate a weighted average of the detected angular rotation rates from the plurality of rotation sensors, the weighted average including the detected angular rotation rate of each rotation sensor about its sensing axis weighted by the detected acceleration along its direction of least acceleration sensitivity.

2. The survey tool of Claim 1, wherein the plurality of rotation sensors comprises a plurality of microgyros.

3. The survey tool of Claim 2, wherein the plurality of microgyros comprises at least one vibrating-wheel microgyro.

4. The survey tool of Claim 2, wherein the plurality of microgyros comprises at least one resonating-mass microgyro.

5. The survey tool of Claim 2, wherein the microgyros comprise a packed unit with the microgyros stacked on one another.

6. The survey tool of Claim 5, wherein the sensing axes of the microgyros of the packed unit are generally parallel to one another.

7. The survey tool of Claim 2, wherein the microgyros comprise a plurality of packed units, and wherein the sensing axes of the microgyros of each packed unit are

generally colinear to one another and to the sensing axes of the microgyros of the other packed units.

8. The survey tool of Claim 7, wherein at least two of the plurality of packed units are spaced apart from one another in the housing.

9. The survey tool of Claim 7, wherein the directions of least acceleration sensitivity of the microgyros of each packed unit are spread substantially equally over approximately 180 degrees.

10. The survey tool of Claim 1, wherein the sensing axis and the direction of least acceleration sensitivity of each rotation sensor are generally perpendicular to one another.

11. The survey tool of Claim 1, wherein the survey tool is part of a wireline geophysical instrument package.

12. The survey tool of Claim 1, wherein the survey tool is part of a drilling system adapted to drill the borehole.

13. The survey tool of Claim 12, wherein the drilling system comprises a drilling tool, and the housing of the survey tool is in proximity to the drilling tool.

14. The survey tool of Claim 12, wherein the drilling system comprises a drilling tool, and the housing of the survey tool is a component of the drilling tool.

15. The survey tool of Claim 12, wherein the drilling system comprises a measurement-while-drilling (MWD) drilling tool.

16. The survey tool of Claim 1, wherein the plurality of rotation sensors comprises at least three microgyros.

17. The survey tool of Claim 1, wherein the directions of least acceleration sensitivity of the plurality of rotation sensors are spread evenly from one another by approximately 60 degrees.

18. The survey tool of Claim 1, wherein the directions of least acceleration sensitivity of the plurality of rotation sensors are spread evenly from one another by approximately 45 degrees.

19. The survey tool of Claim 1, wherein the directions of least acceleration sensitivity of the plurality of rotation sensors are spread unevenly over a range of degrees.

20. The survey tool of Claim 1, wherein the plurality of acceleration sensors are mounted with their sensing directions generally parallel to the directions of least acceleration sensitivity of the plurality of rotation sensors.

21. The survey tool of Claim 1, wherein the controller is at least partially positioned within the housing.

22. The survey tool of Claim 1, wherein the controller is positioned away from the housing.

23. The survey tool of Claim 1, wherein the controller accesses the first signals and the second signals at a discrete frequency.

24. A control system of a rotatably steerable drilling system configured to drill in a selected drilling direction of a plurality of drilling directions, the control system configured to adjust the selected drilling direction, the control system comprising:

a plurality of rotation sensors, each rotation sensor having a sensing axis and a direction of least acceleration sensitivity, each rotation sensor adapted to generate a first signal indicative of a detected angular rotation rate about its sensing axis, the plurality of rotation sensors mounted in a housing with their sensing axes generally parallel to one another and with their directions of least acceleration sensitivity generally non-parallel to one another;

a plurality of acceleration sensors mounted in the housing, each acceleration sensor having a sensing direction, each acceleration sensor adapted to generate a second signal indicative of detected acceleration along its sensing direction; and

a controller adapted to receive a first signal from each of the plurality of rotation sensors and a second signal from each of the plurality of acceleration sensors, the controller adapted to calculate a weighted average of the detected angular rotation rates from the plurality of rotation sensors, the weighted average including the detected angular rotation rate of each rotation sensor about its sensing axis weighted by the detected acceleration along its direction of least acceleration sensitivity.

25. A method of determining an orientation of a survey tool within a borehole, the method comprising:

providing a plurality of rotation sensors, each rotation sensor having a sensing axis and a direction of least acceleration sensitivity, the plurality of rotation sensors having their sensing axes generally parallel to one another and their directions of least acceleration sensitivity generally non-parallel to one another;

obtaining a detected angular rotation rate from each rotation sensor, each detected angular rotation rate being about the sensing axis of the corresponding rotation sensor;

obtaining a detected acceleration along the directions of least acceleration sensitivity of each of the rotation sensors; and

calculating a weighted average of the detected angular rotation rates from the plurality of rotation sensors, the weighted average including the detected angular rotation rate of each rotation sensor about its sensing axis weighted by the detected acceleration along its direction of least acceleration sensitivity.

26. The method of Claim 25, further comprising providing real-time quality control of the weighted average.

27. The method of Claim 26, wherein providing real-time quality control comprises calculating a standard deviation of the weighted average and excluding angular rotation rate measurements that are more than a predetermined number of standard deviations from the weighted average.

28. The method of Claim 27, wherein the predetermined number of standard deviations is three.

29. The method of Claim 26, wherein providing real-time quality control comprises determining which detected angular rotation rate is furthest from the weighted average and recalculating the weighted average by excluding the furthest detected angular rotation rate.

30. The method of Claim 26, wherein each rotation sensor has a direction of most acceleration sensitivity and providing real-time quality control comprises determining which rotation sensors have undergone an appreciable acceleration along its direction of most acceleration sensitivity and recalculating the weighted average by excluding the detected angular rotation rates from said rotation sensors.

31. The method of Claim 26, wherein providing real-time quality control comprises determining which rotation sensors are at temperatures above a predetermined maximum temperature, and recalculating the weighted average by excluding the detected angular rotation rates obtained from said rotation sensors.

32. The method of Claim 26, wherein providing real-time quality control comprises determining which rotation sensors are at temperatures below a predetermined minimum temperature, and recalculating the weighted average by excluding the detected angular rotation rates obtained from said rotation sensors.

33. The method of Claim 25, further comprising active gross error control by monitoring the rotation sensors over time, determining which rotation sensors are having difficulties providing accurate measurements, and recalculating the weighted average by excluding the detected angular rotation rates from said rotation sensors.

34. The method of Claim 25, wherein calculating the weighted average comprises using predictive filtering.

35. The method of Claim 34, wherein using predictive filtering comprises using Kalman filtering.

36. The method of Claim 35, wherein using Kalman filtering comprises avoiding divergence of the Kalman filtering.

37. The method of Claim 35, further comprising real-time tuning of the gain of the rotation sensors.

38. A rotatably steerable drilling system comprising:

- a drill string configured to drill in a selected direction of a plurality of directions, the drill string comprising a drill bit;

- a survey tool in proximity to the drill bit, the survey tool comprising:

- a plurality of rotation sensors, each rotation sensor having a sensing axis and a direction of least acceleration sensitivity, each rotation sensor adapted to generate a first signal indicative of a detected angular rotation rate about its sensing axis, the plurality of rotation sensors mounted in a housing with their sensing axes generally parallel to one another and with their

directions of least acceleration sensitivity generally non-parallel to one another;

a plurality of acceleration sensors mounted in the housing, each acceleration sensor having a sensing direction, each acceleration sensor adapted to generate a second signal indicative of detected acceleration along its sensing direction; and

a controller configured to receive a first signal from each of the plurality of rotation sensors and a second signal from each of the plurality of acceleration sensors, the controller configured to calculate a weighted average of the detected angular rotation rates from the plurality of rotation sensors, the weighted average including the detected angular rotation rate of each rotation sensor about its sensing axis weighted by the detected acceleration along its direction of least acceleration sensitivity, the controller further configured to generate a third signal indicative of the weighted average;

and

a steering mechanism configured to adjust the selected direction in response to the third signal from the controller.